Commercial

Outline

- Commercial Building Stock Assessment
- Commercial-Sector Lighting Overview
  - Baselines & Efficiency Measures
  - Some Key Measure Costs & Savings
  - Areas for Committee Feedback

Commercial Building Stock Assessment
CBSA Gives Picture of Building Stock 2013

New Sample Frame	270,000 building records
812 Buildings Sampled	46 million square feet sampled
12 Building Types	Across all four states
Statistical Cohorts	Pre/Post 2004, Urban/Rural, Size Class
Nearly 800 Variables	
Over 600 Sites with Monthly Billing Data	
14,000 Records for Lighting Fixture Class	Lower Lighting Power Density (LPD)
2400 Records for HVAC Systems	More electric heating than previous
Renovation Frequency by System Type	
Info on Embedded Data Centers	A significant load (1 in 3 buildings)

All CBSA Data:
Excludes Hospital and University

Commercial Building Stock

3.1 Billion SF & 203,000 Buildings

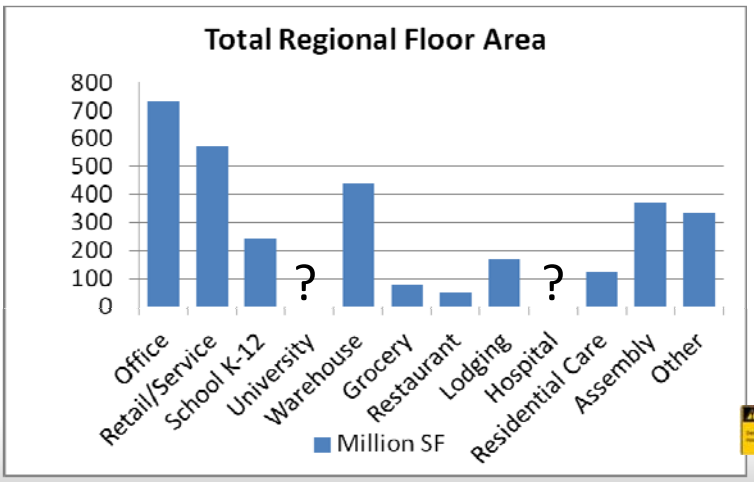


Figure 2. Map of Urban and Rural Classification for 2014 CBSA

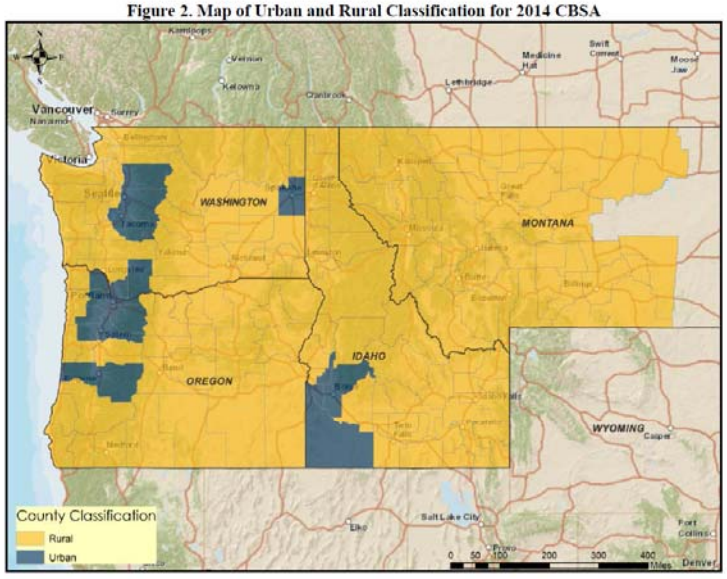
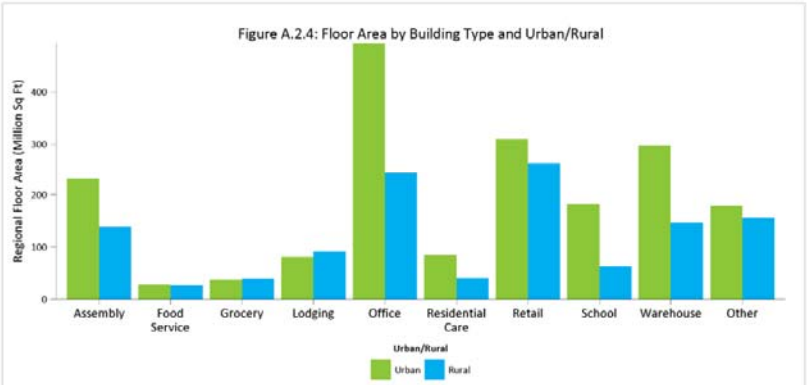


Figure A.2.4: Floor Area by Building Type and Urban/Rural



Urban/Rural	Assembly	Food Service	Grocery	Lodging	Office	Residential Care	Retail	School	Warehouse	Other
Urban	231	27	37	81	492	85	309	182	297	178
	63%	52%	48%	47%	67%	68%	54%	74%	67%	53%
Rural	138	26	40	90	242	40	262	63	146	155
	37%	48%	52%	53%	33%	32%	46%	26%	33%	47%

Units: Regional Floor Area (Million Sq Ft), % of column total

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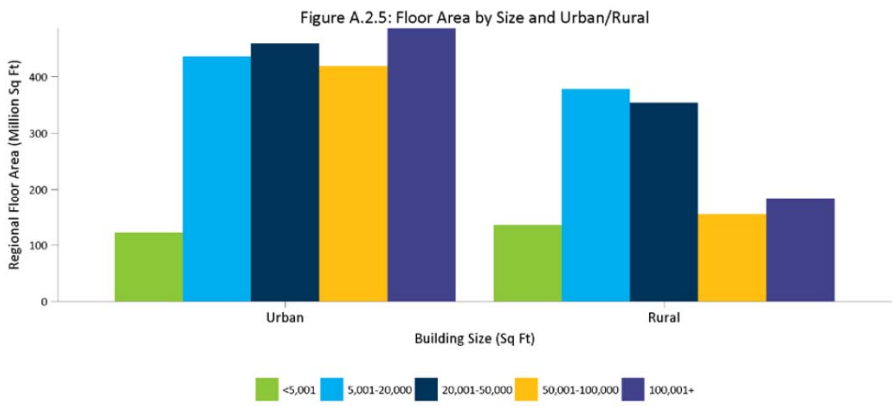
Figure A.2.5: Floor Area by Size and Urban/Rural



Urban/Rural	<5,001	5,001-20,000	20,001-50,000	50,001-100,000	100,001+
Urban	121	435	459	418	485
	6%	23%	24%	22%	25%
Rural	135	378	354	154	182
	11%	31%	29%	13%	15%

Units: Regional Floor Area (Million Sq Ft), % of row total

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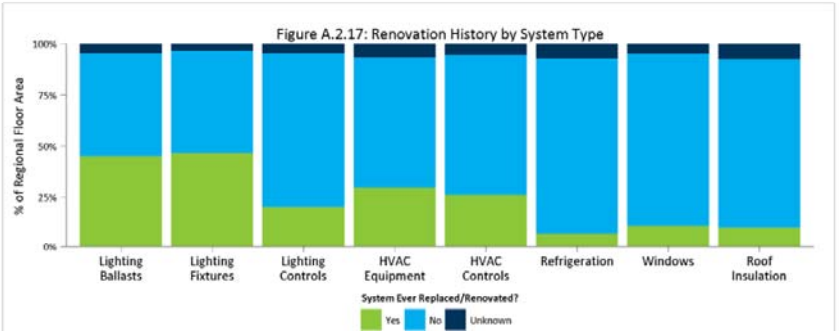
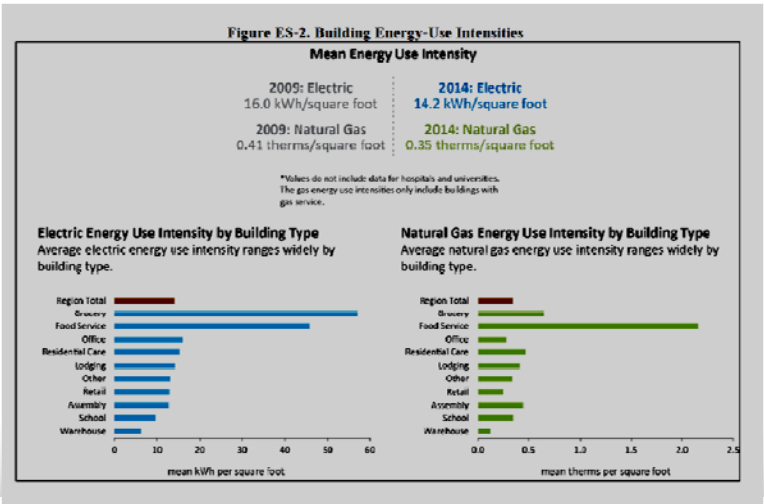
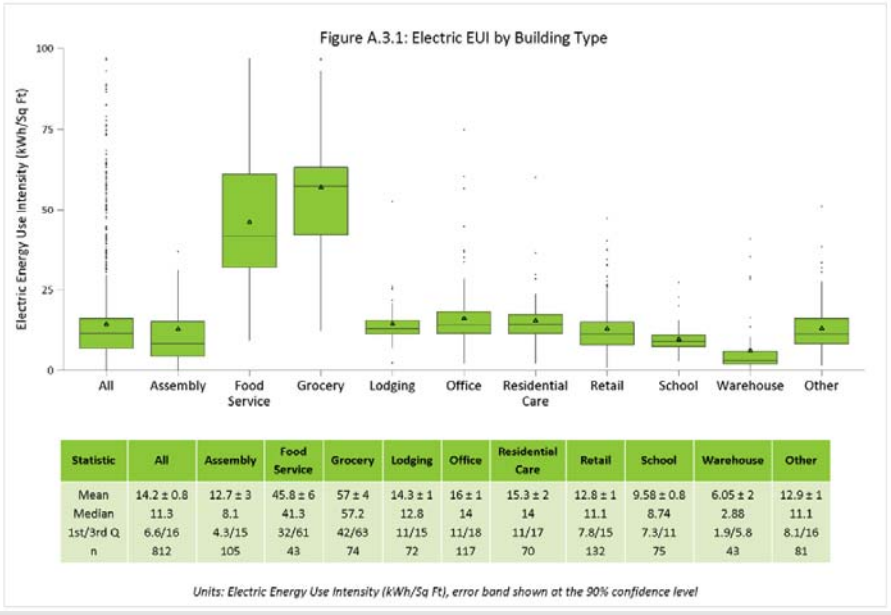


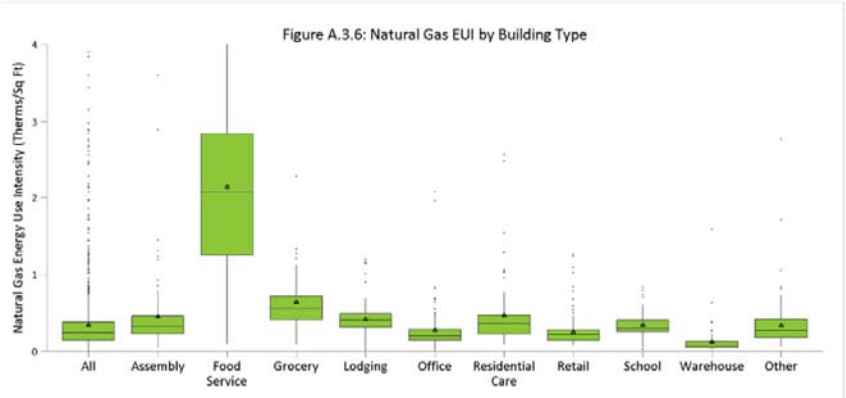
Lower Estimates of Energy Use Intensity 16.0 to 14.2 kWh/sf





Statistic	All	Assembly	Food Service	Grocery	Lodging	Office	Residential Care	Retail	School	Warehouse	Other
Mean	14.2 ± 0.8	12.7 ± 3	45.8 ± 6	57 ± 4	14.3 ± 1	16 ± 1	15.3 ± 2	12.8 ± 1	9.58 ± 0.8	6.05 ± 2	12.9 ± 1
Median	11.3	8.1	41.3	57.2	12.8	14	14	11.1	8.74	2.88	11.1
1st/3rd Q	6.6/16	4.3/15	32/61	42/63	11/15	11/18	11/17	7.8/15	7.3/11	1.9/5.8	8.1/16
n	812	105	43	74	72	117	70	132	75	43	81

Units: Electric Energy Use Intensity (kWh/Sq Ft), error band shown at the 90% confidence level

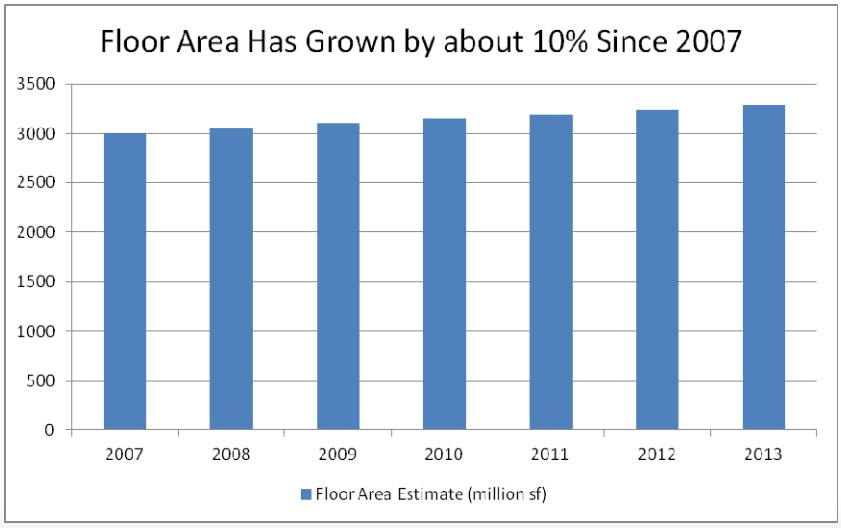


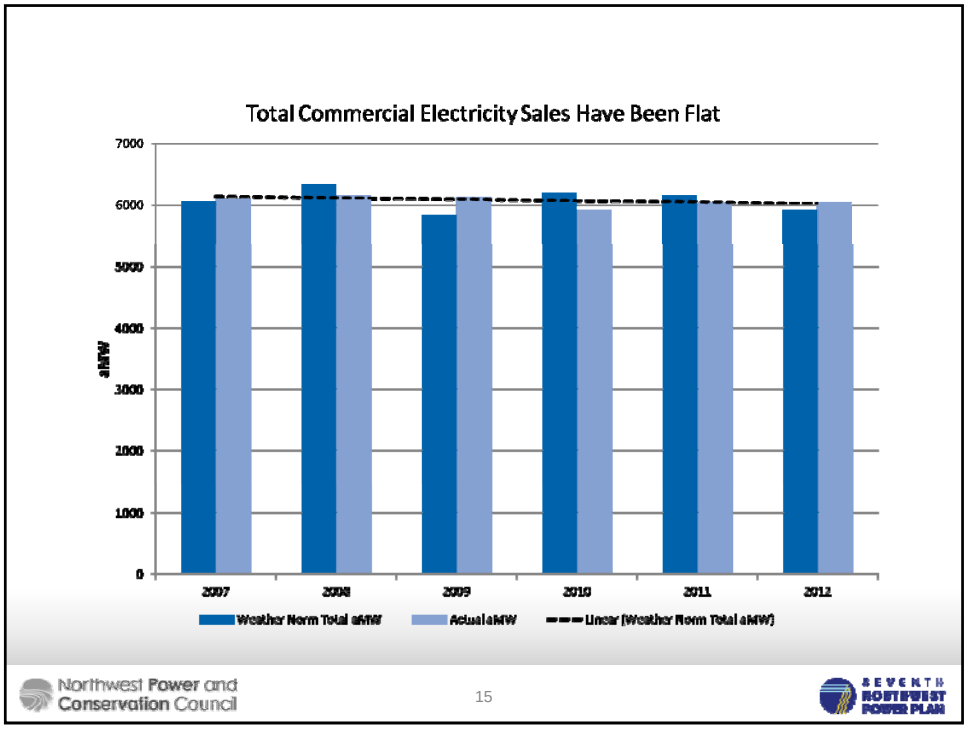
Statistic	All	Assembly	Food Service	Grocery	Lodging	Office	Residential Care	Retail	School	Warehouse	Other
Mean	0.35 ± 0.03	0.45 ± 0.08	2.15 ± 0.3	0.64 ± 0.1	0.42 ± 0.04	0.28 ± 0.06	0.47 ± 0.09	0.25 ± 0.03	0.35 ± 0.03	0.13 ± 0.06	0.34 ± 0.06
Median	0.24	0.32	2.07	0.56	0.4	0.2	0.36	0.22	0.3	0.07	0.27
1st/3rd Q	0.15/0.38	0.23/0.46	1.2/2.8	0.41/0.72	0.31/0.49	0.15/0.29	0.23/0.47	0.15/0.28	0.26/0.4	0.049/0.13	0.18/0.41
n	668	81	41	50	66	79	66	112	68	36	69

Units: Natural Gas Energy Use Intensity (Therms/Sq Ft), error band shown at the 90% confidence level

Believable?

- Compare to utility-reported sales data
  - EIA data reported by utility by sector
- And estimates of floor area change
  - Data from FW Dodge new construction database
  - Estimates from Council econometric models




Total Commercial Electricity Sales Have Been Flat
7000
6000
5000
4000
3000
2000
1000
0
aMW
2007
2008
2009
2010
2011
2012
Weather Norm Total aMW
Actual aMW
Linear (Weather Norm Total aMW)
Northwest Power and Conservation Council
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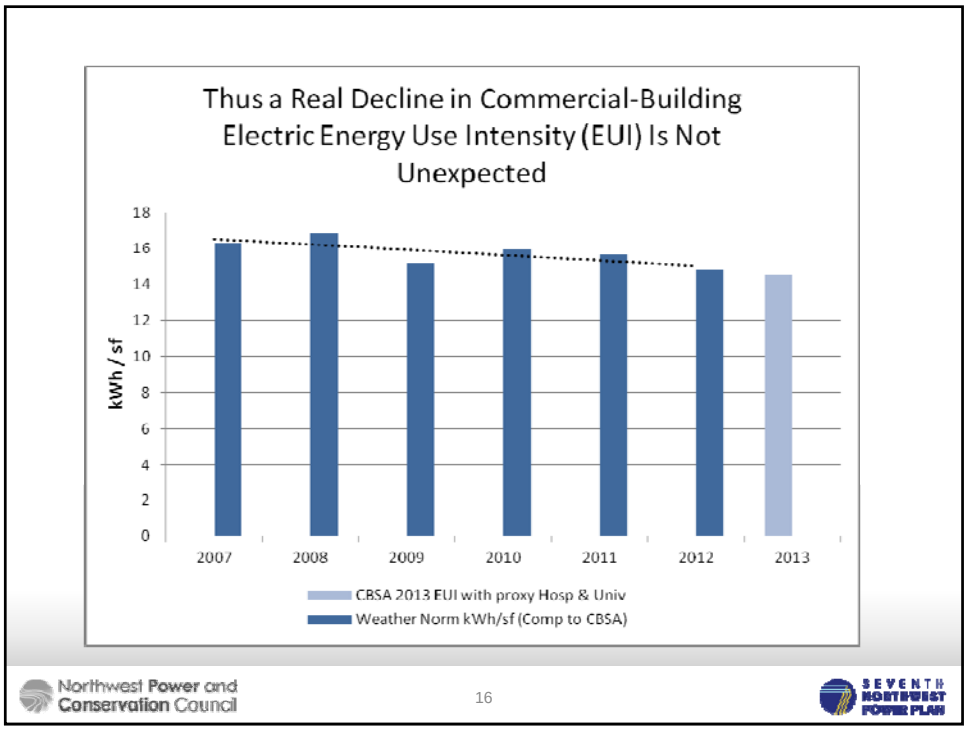
Thus a Real Decline in Commercial-Building Electric Energy Use Intensity (EUI) Is Not Unexpected
18
16
14
12
10
8
6
4
2
0
kWh / sf
2007
2008
2009
2010
2011
2012
2013
CBSA 2013 EUI with proxy Hosp & Univ
Weather Norm kWh/sf (Comp to CBSA)
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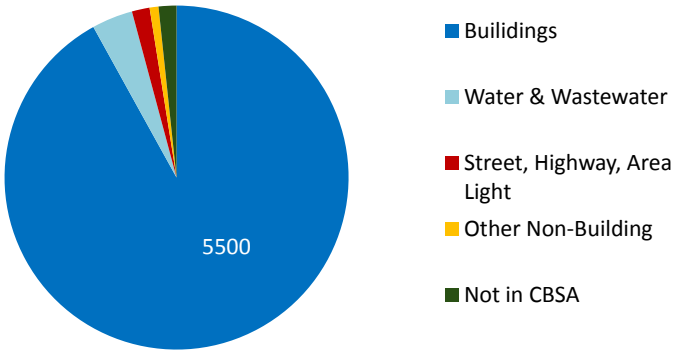
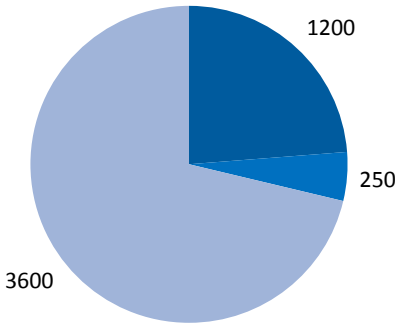
6000 aMW Electric Sales 2013



LIGHTING

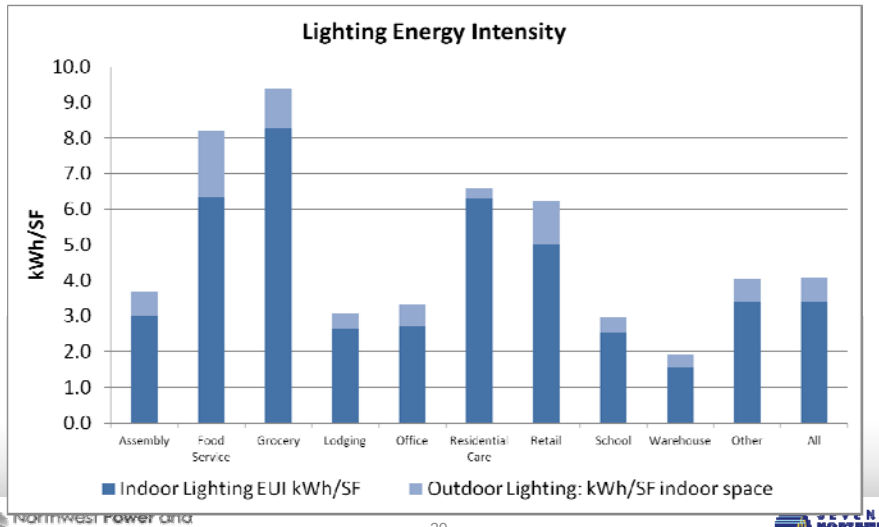
Lighting Uses about 30% of Total Commercial Building Electricity

2013 Site Energy for Buildings in aMW

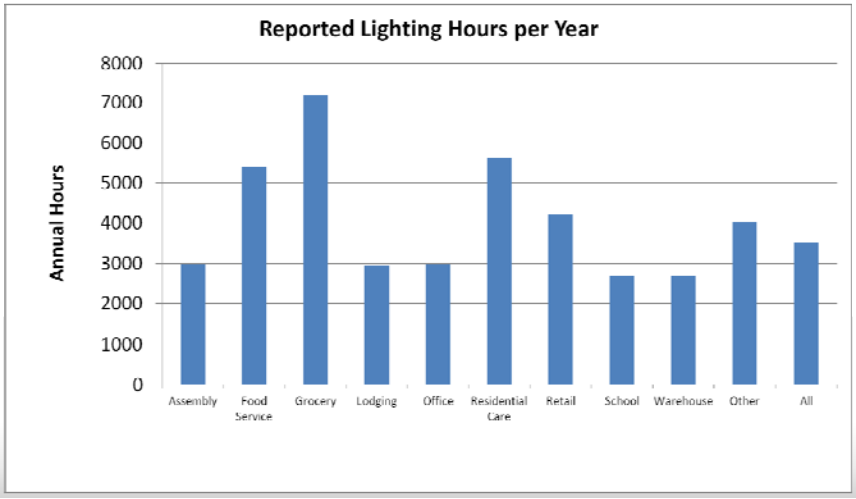


Lighting Indoor Lighting Outdoor Other Site Energy

Lighting Energy 2 to 10 kWh/SF



About 3500 Lighting Hours per Year



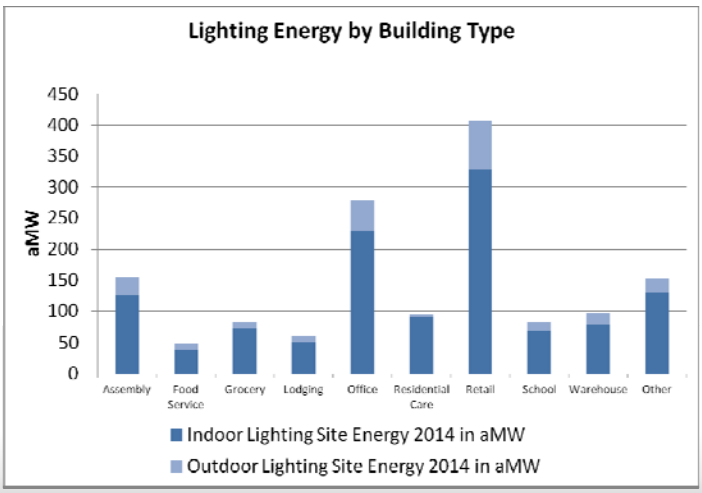
CBSA Lighting Hours are 20% Lower than National Lighting Inventory

Table 6.2.1 Average Operating Hours by Sector and Lamp Type

Sector	Lamp Type	Average Annual Operating Hours *hr/year*
Residential	GSFL	648
	IRL	761
Commercial	GSFL	4,058
	IRL	4,496
Industrial	GSFL	4,585

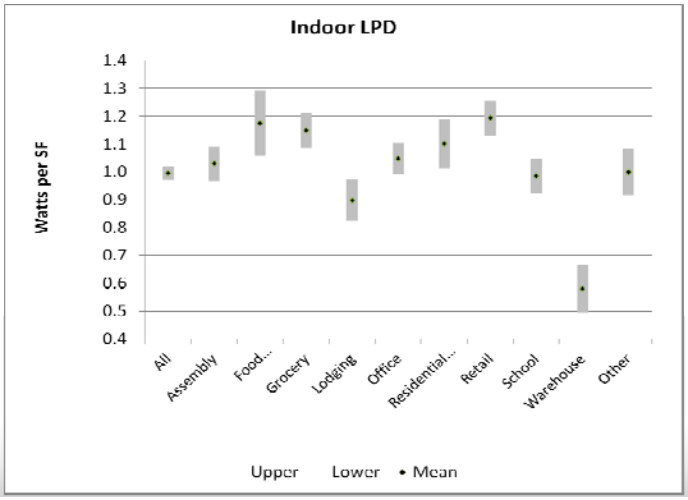
Table Reference: DOE 2014 NOPR on General Service Fluorescent Lighting. Source data from 2010 National Lighting Market Characterization. Data are building operating hours taken from surveys with unknown number of building owners and operators.

Office & Retail Are Biggest Lighting Energy Consumers

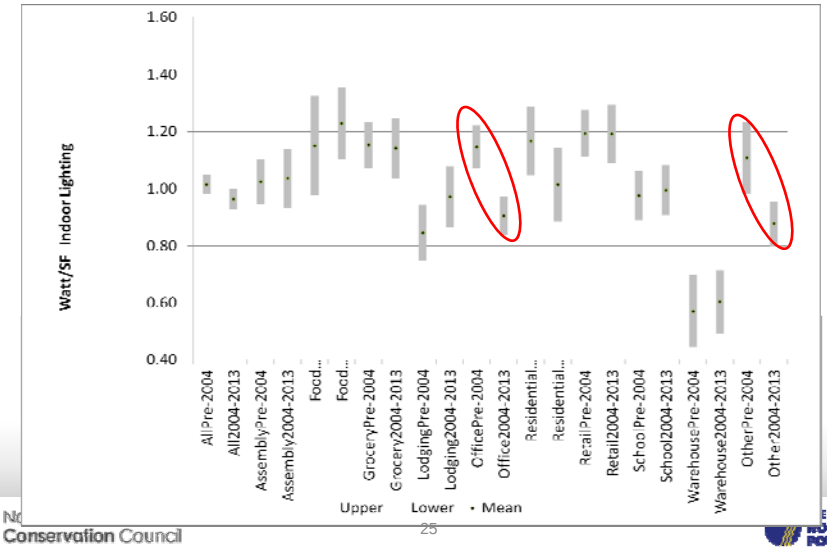


Uncertainty About Mean LPD

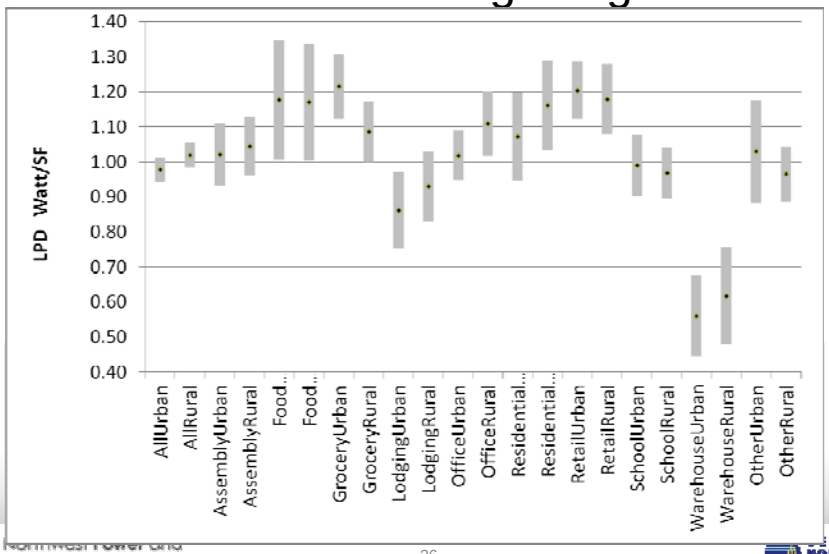
(95% C.I.)



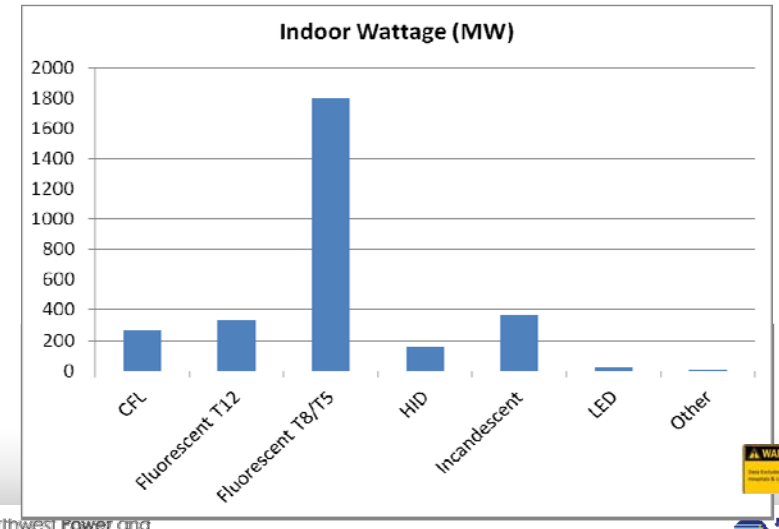
Little Difference in LPD by Vintage : Except Offices & Other



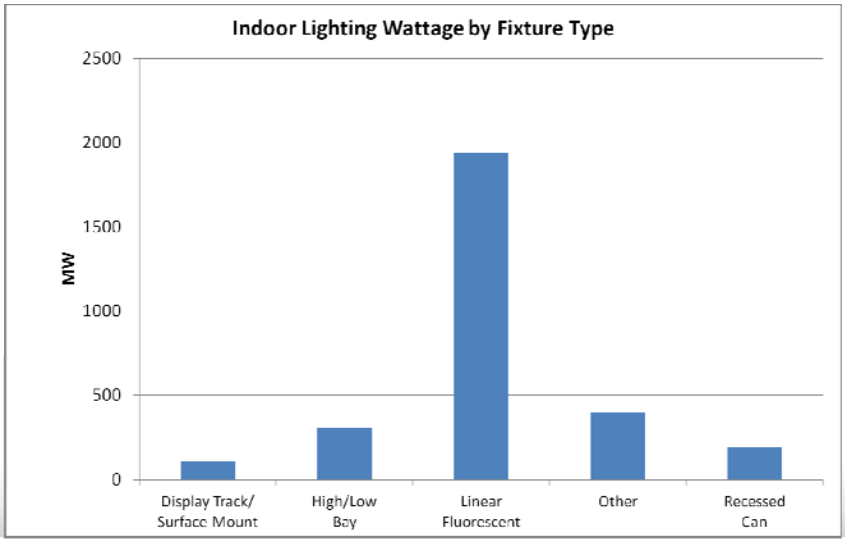
No Statistical Difference Between Urban and Rural Lighting Power



Over 2900 MW Indoor Lighting
by Lamp Type

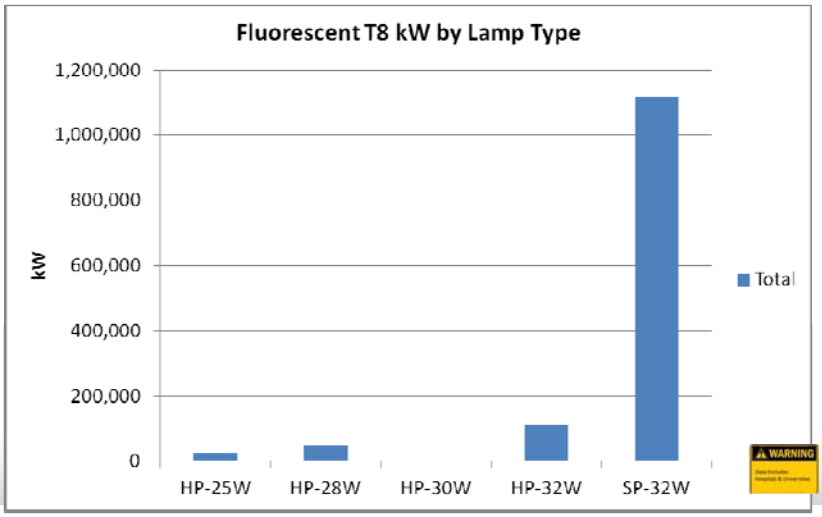


Linear Fluorescent Dominates Fixture Type

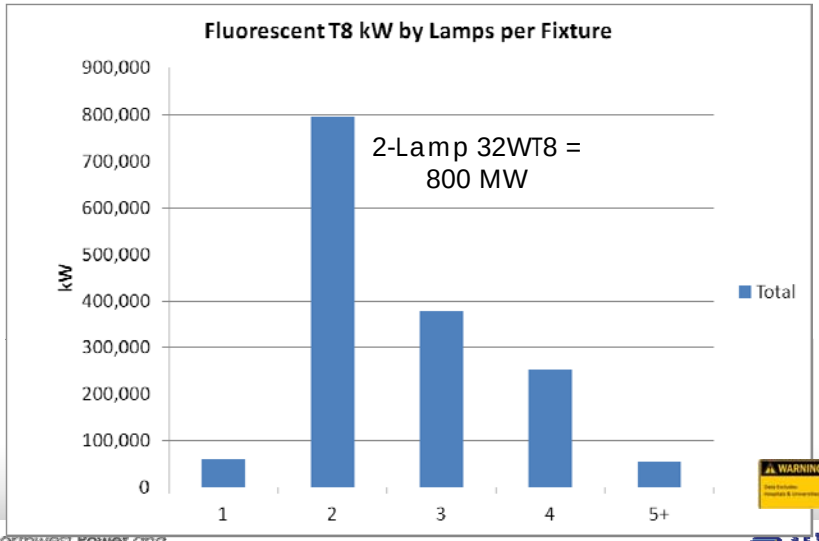


Standard Performance T8 Dominate Stock

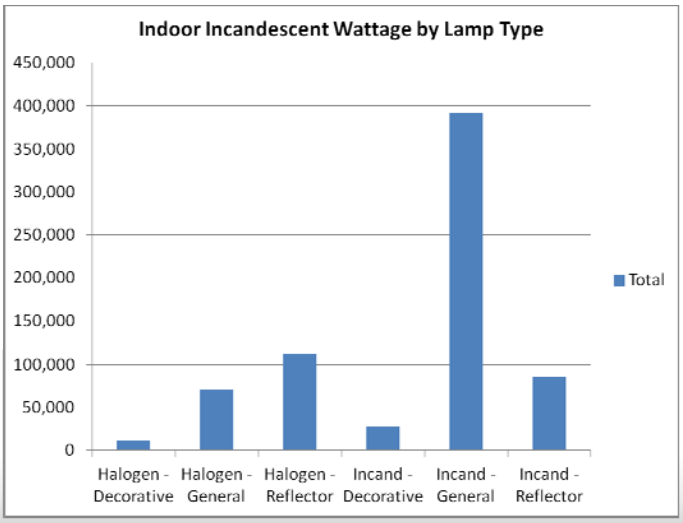
(So a Change to High Performance T8 is a Strong Measure)



Lamps Per Fixture Distribution (32WT8)



700 MW of Incandescent



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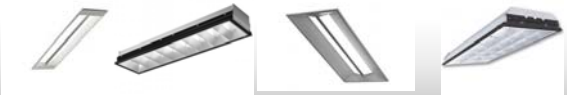
Linear Fluorescent Fixtures

Common Sizes from CBSA (Total Watts)

	4 feet x 2 feet	4 feet x 1 feet	All Other LF Fixtures 2x2, 8x1, 8x2,…
Surface Mount	12%	12%	
Pendant	3%	13%	
Recessed	33%	5%	
Unknown	3%	1%	
Total	**52%**	**31%**	**17%**



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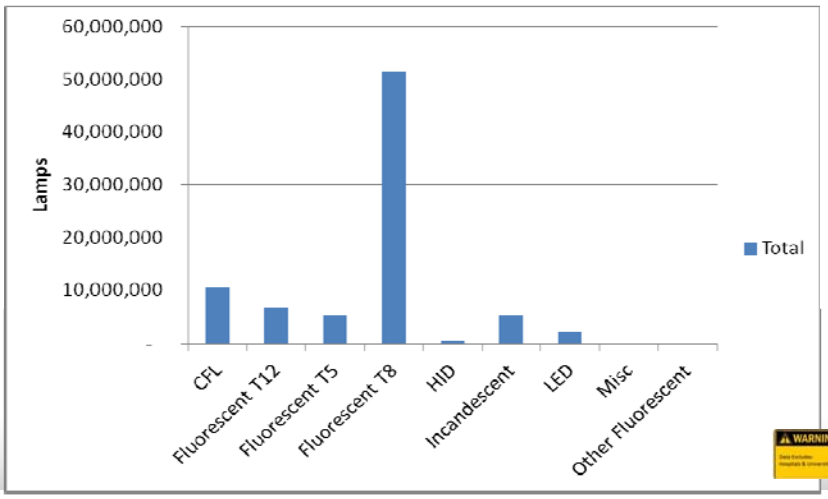
SEVENTH NORTHWEST POWER PLAN

Over 82 Million Lamps Total (50 million T8)



Commercial Lighting Savings Potential

Three Classes of Lighting Measures

1

Lamp Replacement on Burnout
(LF: T8 to Low-Watt T8)
(Also A-19, Reflector)

Subject to Federal Standard Baselines
New Fed. Standard for LF & IRL Proposed Effective 2018

2

One-for-One Fixture Replacements - Not Subject to State Code
Mostly Solid State Options by Application:
Linear Fluorescent, High Bay, Directional, Recessed Cans

3

Lighting Remodel: Redesign at Time of Lighting Remodel and in New Buildings & Additions
Efficient Fixtures, Sources, Design, & Controls
Drive Lighting Power Density to Best in Class & Reduce Burn Time
State Code Baselines

Following Sections Describe the Approach to Estimating Savings in Each Class

Council is Looking for Feedback on Approach and Data Sources

Class 1: Lamp Replacement Linear Fluorescent

(Lamp Maintenance Market)

- Based on Current Federal Rulemaking
  - General service fluorescent lighting & incandescent reflector lamps (GSFL & IRL)
- Rulemaking in progress now
- Proposed effective date 2018
- If adopted before 7P, adopt savings in forecast
- If not, savings remain as EE resource

Class 1: Lamp Replacements Linear Fluorescent

Baseline is Current Standard NOT "In Ceiling"

LF T8 Lamps
Minimum 89 lm/Watt
(Fed Standard July 2014)

LF Ballasts
High BLE
(Fed Standard Nov 2014)

LF T12 Lamps
NOT IN BASELINE

Magnetic Ballast
NOT IN BASELINE

Assume no Fixture Change

This may to too conservative.

Only 4% of T8 ballast stock is High Performance.

Cost & Savings Elements
Low-Watt T8 Lamp Replacement

Element	Note	Source
Measure	25 Watt & 28 Watt HP T8 Fluor 93 lumens/Watt minimum 800 Series Phosphors	DOE GSFL Rulemaking
Unit Energy Use	System Watts per Lamp	DOE GSFL Rulemaking
Savings	System Watts per Lamp (6 to 9 Watts/lamp)	DOE GSFL Rulemaking
Cost	Incremental over minimum federal standard (89 lm/Watt) $1 to $2 per lamp	1000 Bulbs.com
Hours & HVAC Interaction	By building type	CBSA
Lamp/Labor Replacement Savings	None. Assume like-for-like hours per lamp	

Units Estimates
Low Watt Fluorescent

Element	Note	Source
Lamp Count	52 million T8 6 million T12	CBSA
Turnover Rate	7 years average	Lamp Life/Hours per Year
Baseline Stock Saturation	7% of installed T8 are Low-Watt	CBSA
Baseline Sales Penetration	20% of T8 sales are Low-Watt as baseline	BPA/Navigant 2013
Annual Availability	6.8 million lamps per year	Lamp count/life

Initial Cost & Savings Results
Low-Watt Fluorescent

Element	Note	Compared to 6P
Total Achievable Savings Available if Federal Standard	80 aMW	Not in 6P
Annual Achievable Savings Maximum	10 aMW/Year	
Total Achievable Program Savings Available (85%)	68 aMW	
Levelized Cost	$6 to $11 per MWh	
Proposed Ramp Rate	Fast: 20% to 85% in 5 years	

Feedback
Low-Watt Fluorescent Lamp Replacement

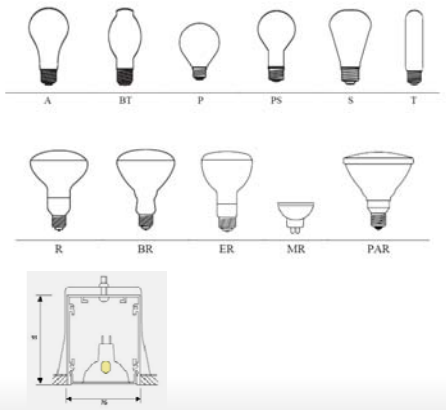
- Baseline ballast
- Lamp cost increment?
- Mix of 25W, 28W & 32W?
- Lower light levels by ~10%
- Ramp rate

What About T8 LED Replacements?

- Marginal savings over Low-Watt T8
- Expensive ($24/tube versus $2/tube)
- Sub par reviews
  - PNL in-situ performance & visual tests 2013
- Initial levelized cost estimates
  - $180/MWh
  - $130/MWh with lamp/labor change savings
- Still saddled with existing fixture (~70% efficient)
  - Does not take advantage of LED form factor
- Proposal:
  - Exclude T8 LED one-for-one lamp from analysis
  - Focus on LED fixtures for LF replacements

Feedback
T8 LED

Class 1: Lamp Replacements Screw- and Pin-Based Options



Cost & Savings Elements
Screw-Base Lamp Replacement

Element	Note	Source
Measures	Directional (Halogen PAR) to LED General Service A-19 to LED Downlights to LED	
Baseline	Various	Federal Standards EISA 2020 Baseline for GS
Unit Energy Use	System Watts per Lamp	DesignLights Consortium, Lighting Facts , ENERGYSTAR
Savings	Delta Watts * Hours Adjusted for HVAC interaction	LED performance forecast to 2017 levels
Cost	Incremental over minimum federal standard	ENERGYSTAR, sales data, web: Forecast to 2017
Baseline Penetration	Varies by application	CBSA Sales data if available
Lamp/Labor Replacement Savings	Include	Lamp & Labor Cost

Units Estimates

Screw-Base Lamp Replacement

Element	Note	Source
Lamp Count	Display Track: 2.8 million General Service A-19: 11 million Recessed Can: 5.3 million	CBSA
Baseline Stock Saturation	Display: 20% CFL, 20% LED, 60% INC GS: 50% CFL, 12% LED, 30% INC Recessed: 73% CFL, 5% LED, 20% INC Reach-In Cases: 56% LED	CBSA
Baseline Sales Penetration	Baseline stock or better	Sales Data if Available
Annual Availability	Baseline lamp life / Annual burn hrs Lamp count/turnover rate	

Class 1: Lamp Replacements Results for Screw-Base Options

TBD

Technology	Expected Results
SSL versus Halogen	Large Savings / Lamp Low Levelized Cost
SSL versus CFL	Lower Savings /Lamp, Higher Cost
SSL in Refrigeration Cases	Strong Savings / Case But 56% done in reach-in cases Low saturation in display cases

Feedback
Screw-Base Lamp Replacements

- General Service Baseline
  - Propose EISA 2020 45 lm/Watt
  - Ignore higher savings 2016-2020?

Class 2: One for One Fixture Replacement

- Fixture Replacement Rate from CBSA
  - About 5% per year
- Total Linear Fluor Fixtures Installed = 26 million
  - Max Annual Replacement Rate = 1.3 million/year
  - Assume 70% not subject to State Code LPD minimums
- Present Opportunity for EE Upgrade
  - Upgrade at lower incremental cost

Class 2: One for One Fixture Replacement

- Indoor Proxy Measures
  - LF Fixture to High Perf-LF Fixture (HP-LF-Fix)
  - LF Fixture to HP-LED
  - High Bay HID Fixture to HP-LF-Fix
  - High Bay HID Fixture to HP-LED
  - Recessed Cans to LED
- With Occupancy Controls
  - Office & Warehouse & Stairwell

Class 2: One for One Fixture Replacement Outdoor

- Mostly Parking & Façade Lighting (CBSA)
- Outdoor & Parking Proxy Measures
  - Wall Pack HID to LED
  - Parking HID to LED
- With Bi-Level Occupancy Controls

Cost & Savings Elements
One-for-One Fixture Replacements

Element	Note 1	Source
Measures	Six Indoor Proxy Measures Two Outdoor Proxy Measures	
Baseline	Replacements not subject to State Code Standard Perf Fixtures Minimum Federal Std Lamp & Ballast	Industry experts
Unit Energy Use	System Watts per Fixture	Industry experts
Savings	Delta Watts * Hours Adjusted for HVAC interaction	
Cost	Incremental cost over standard perf	Industry experts Forecast LED to 2017
Lamp/Labor Replacement Savings	Include	Lamp & Labor Cost

Units Estimates
One-for-One Fixture Replacements

Element	Note 1	Source
Floor Area for Lighting Remodel/Renovation	Average 5% annual turnover ~150+ million sf/year Assume 30% subject to Code 70% available for measures	CBSA fixture renovation data
Number of Fixtures	26 million Linear Fluor/year 4.8 million High Bay 4.7 million Recessed Can	CBSA
Baseline Stock Saturation	Linear Fl: HPT8: 17%, ??LED HighBay: 36% T5, 24% HID, < 1% LED Recessed: 73% CFL, 5% LED, 20% INC	CBSA
Baseline Sales Penetration	Assume 20%	Update with sales data if available
Ramp Rate	Moderate	

Class 2: One-for-One Fixture

Initial Results

TBD

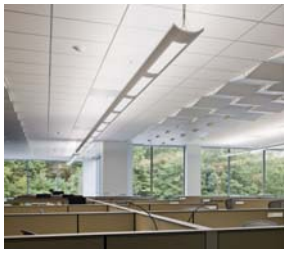
Technology	Expected Results
LF Fixture to HP-LED	
High Bay HID Fixture to HP-LED	
Recessed Can to LED	

Key Feedback Questions

One-for-One Fixture Replacements

- Baseline
  - Propose current practice equipment (federal min)
  - Not "In Ceiling" equipment
- Available Units
  - Propose 5% turnover rate
  - 1.3 million LF Fixtures per year
  - Assume 70% not subject to State Code LPD
- Ramp Rate
  - Moderate

Class 3: Lighting Remodel & Design

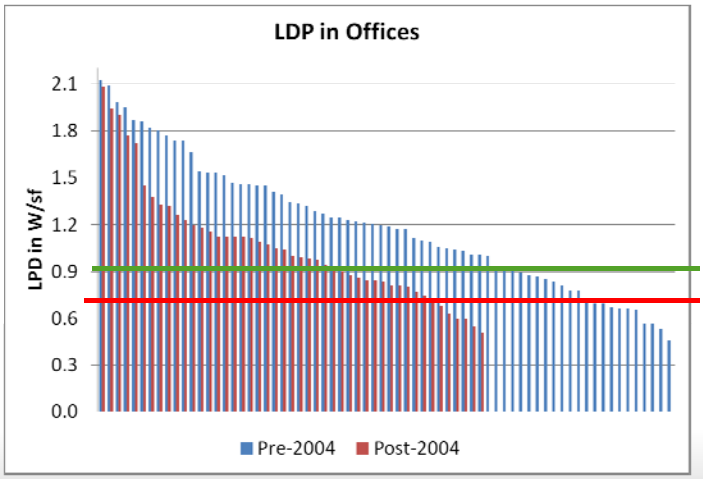




Cost & Savings Elements
Lighting Remodel & Design

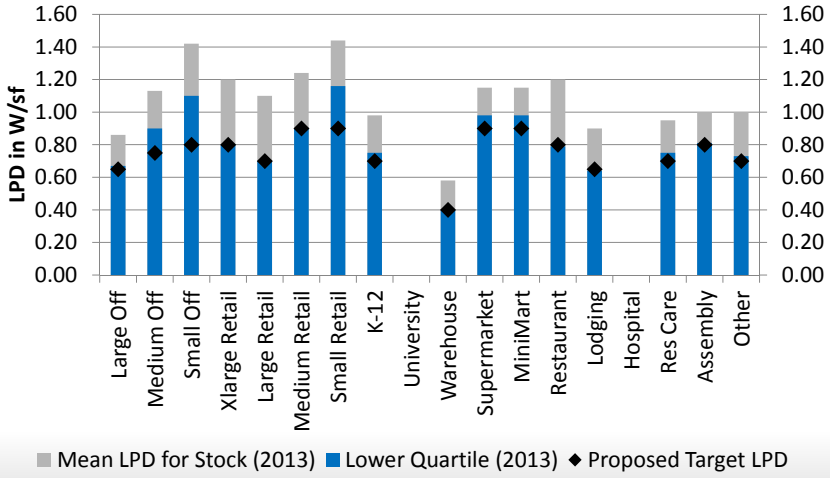
Element	Note	Source
Measure	Efficient Fixtures, Sources, Design, & Controls. Drive to Best-in-Class LPD & Reduce Burn Time	
Baseline	State Code Baselines	States
Savings	About 0.3 W/sf - 30% over code Based on lower quartile of existing Lighting Power Density or better	CBSA Case Studies
Control Savings	Office Warehouse	
Cost	Range $0 to $1 per sf Design, equipment, labor & markup	Design Professionals Case Studies
Current Saturation	About 20%	CBSA

Lighting Power Density & Example Savings Potential in Office Lighting



LPD	
Mean	1.05
Median	1.10
Code	0.91
Target	0.70

Setting Target LPDs for New & Remodeled Lighting



Units Estimates

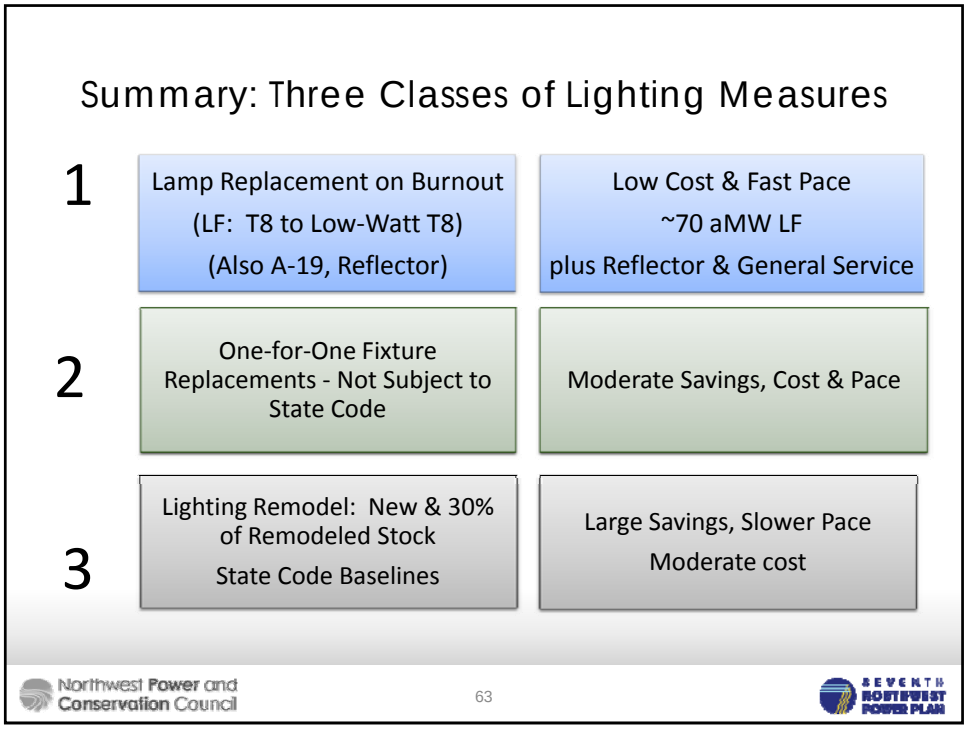
Lighting Remodel & Design

Element	Note	Source
Floor Area New	About 50 million sf/year 100% subject to State Code	Council forecast
Floor Area for Lighting Remodel/Renovation	Average 5% annual turnover 150+ million sf/year remodel Assume 30% subject to Code So 50 million sf/year	CBSA fixture renovation data
Baseline Saturation	About 15% - 20% at or better than target	CBSA
Ramp Rate	Moderate	

Initial Cost & Savings Results

Lighting Remodel & Design

Element	Note	Compared to 6P
Total Achievable Savings Available	About 1.1 kWh/sf LPD ~250 aMW by 2035	Similar
Annual Achievable Savings Max	About 10 aMW per year	
Levelized Cost	TBD	
Proposed Ramp Rate	Slow	Same
Additional Control Savings	Office & Warehouse Luminaire Level Control Stairwell & Corridor	


Summary: Three Classes of Lighting Measures
1
Lamp Replacement on Burnout
(LF: T8 to Low-Watt T8)
(Also A-19, Reflector)
Low Cost & Fast Pace
~70 aMW LF
plus Reflector & General Service
2
One-for-One Fixture Replacements - Not Subject to State Code
Moderate Savings, Cost & Pace
3
Lighting Remodel: New & 30% of Remodeled Stock
State Code Baselines
Large Savings, Slower Pace
Moderate cost
Northwest Power and Conservation Council
63
SEVENTH NORTHWEST POWER PLAN